Joint Cannery Outfall Coral Reef Survey: March 2005 Pago Pago American Samoa

Submitted by:
Starkist Samoa
NPDES Permit AS00000019
COS Samoa Packing
NPDES Permit AS0000027

Submitted to:

U.S. Environmental Protection Agency
American Samoa Environmental Protection Agency

CH2M HILL May 2006

JOINT CANNERY OUTFALL CORAL REEF SURVEY REPORT MARCH 2005 SURVEY

Submitted to:

U.S. Environmental Protection Agency – Region 9 and American Samoa Environmental Protection Agency

Submitted by:

StarKist Samoa, Inc.

NPDES Permits AS0000019

and

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COS Samoa Packing Company
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Executive Summary

The year 2005 coral reef survey was conducted in Pago Pago Harbor as required by the StarKist Samoa and COS Samoa Packing NPDES permit conditions. The survey was conducted during March 2005. This survey represents the sixth coral reef survey conducted at the same sites since 1991. Four locations near the cannery wastewater discharge were surveyed.

The required series of coral reef surveys is designed to provide data needed to evaluate potential impacts of treated wastewater discharged from the Joint Cannery Outfall (JCO) on the nearby coral reef. The coral reef surveys provide information needed to evaluate and detect significant differences, if any, from an earlier study done in January of 1991. The survey sites and data collected in March 2005 were consistent with the 1991 study, and the previous results of the 1993, 1995, 1997, and 2002 surveys.

The survey was done by making video recordings of transects along constant depth contours at three depths at each site. The video recordings were then analyzed and summarized by a qualified marine ecologist with expertise in coral reef taxonomy and previous experience in American Samoa. The survey data are presented in terms of estimated hard coral coverage and the number of hard coral species identified for each transect. The surveys and the analysis of the video records were done by the same staff that conducted all of the previous surveys.

Prior to February 1992 the wastewater discharge from the canneries were through two short outfalls located in the inner Harbor. The discharge point for the canneries was relocated to the outer Harbor using the JCO. In addition, the canneries instituted high strength waste segregation in August of 1990, using an EPA approved ocean disposal site for the high strength wastes. When compared with previous surveys, the survey data for the sites studied in 2005 indicates a general improvement at three of the four sites. The fourth site shows no signs of degradation, and may also be improving, but appears to be influenced by sediment loads from a nearby stream. The site closest to the JCO discharge shows no evidence of wastewater impacts or settleable solids. A potential improvement in coral growth has been observed at this station. Since the discharge plume in the outer Harbor is trapped deeper than 60 feet most, if not all, of the time, no impact from the relocated discharge is expected in the middle or outer Harbor.

Any impacts to coral reef communities due to high strength waste segregation and outfall relocation are expected to be long term and difficult to distinguish from variability caused by other factors. The results from the previous coral reef surveys support this expectation and no definitive observable trends in reef coral communities were previously obvious based on the survey data. This was not unanticipated. However, over the timer period of the series of surveys appears to show a quantifiable improvement in the coral reef communities at the sites surveyed in 2002 and 2005. The effect of a recent hurricane between these two surveys may be responsible for a observed decrease in coral coverage in shallower water.

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1. INTRODUCTION

This report presents the field survey results of coral reef surveys in the middle, and outer regions of Pago Pago Harbor, American Samoa. The survey was conducted March 1-4, 2005 and is the fifth in a series of required surveys and the sixth survey to be conducted at the designated stations using the same methods and scientific staff.

1.1 Purpose

The purpose of this report is to present the results of the most recent (March 2005) coral reef survey and compare the results to previous surveys. The survey is intended to provide information for comparison with past and future surveys. This work was conducted to comply with conditions of the United States Environmental Protection Agency (EPA) NPDES Permit No. AS0000019 for Star-Kist Samoa Inc. and NPDES Permit No. AS0000027 for COS Samoa Packing Company, Inc.

1.2 Background

The coral reef surveys are required under Section G of the current NPDES permits, which states the following:

"The canneries (StarKist Samoa and COS Samoa Packing) shall cooperatively continue the coral reef survey based on the previously approved study plan for the monitoring conducted during 1993-1997 with the modifications described below. The purpose of the study is to assess the potential impacts of the discharge on the nearby coral reef. The intent of the survey is to detect significant differences, if any, from the previous surveys. VCR formatted video copies and a report of results shall be submitted to the ASEPA and USEPA with reports within 120 days of the survey.1

The survey will be done twice during the permit period, once in year two of the permit and once in year 5 of the permit. These surveys will include a subset of the previous transect locations. Transect locations to be surveyed are MH-1, MH-4, OH-5, and OH-I (see Figure 3 [Figure 2 in this report]). After reviewing the results of the first survey, ASEPA and USEPA may require different or additional transacts during the second survey and/or additional surveys."

As indicated in the permit condition above, this survey continues the work required under the previous permit (Section I), which required:

"Within six months of the effective date of this NPDES permit, the permittee, in cooperation with {Samoa Packing Co.; Star-Kist Samoa}, shall submit a field study design for approval by ASEPA and EPA Region 9 to assess the potential impacts of the discharge on the nearby coral reef. The study shall include coral reef transects which shall conform to locations found on Figure 4 in the <u>USE ATTAINABILITY AND SITE-SPECIFIC CRITERIA ANALYSES</u>; <u>PAGO PAGO HARBOR, AMERICAN SAMOA, FINAL REPORT</u> (CH2M HILL, March 15,

¹ The scientist reviewing the video tapes could not meet this schedule. Since this was the same person that had done the reviews for all other surveys both EPA and ASEPA agreed to relax this schedule to maintain consistency with previous reports.

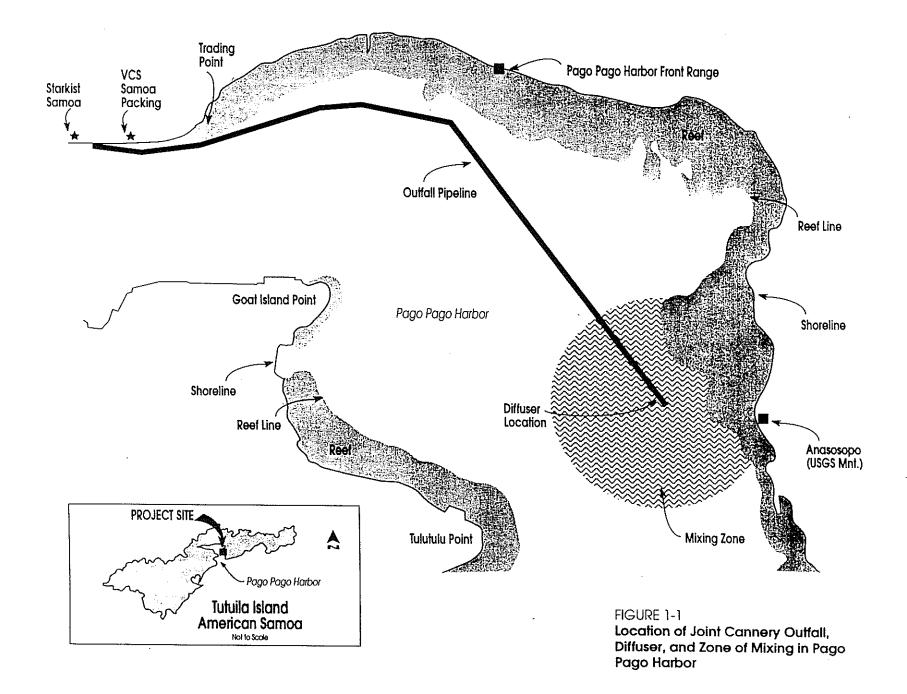
1991). The intent of this annual survey is to detect significant differences, if any, from the database information found in the above-cited document. Videos shall be submitted to both the USEPA and ASEPA. Guidance for designing such surveys is provided in the Design of 301(h) Monitoring Programs for Municipal Wastewater Discharges to Marine Waters November 1982, EPA #430/0-82-010 (pages 70-71). In addition, the discharger should consult Ecological Impacts of Sewage Discharges on Coral Reef Communities, September 1983, EPA #430/9-83-010, for further information. The study shall be conducted within one year of the effective date of this permit and every two years thereafter."

A Coral Reef Survey Study Plan was submitted for review and approval to the EPA and ASEPA on January 8, 1993. The study plan was designed, to the extent possible, to be consistent with a previous study done by CH2M HILL in January 1991 as referenced above in the permit condition. During the development and review of the Coral Reef Survey Study Plan, comments received from USEPA and ASEPA were reviewed and incorporated into the study plan, as necessary. The study plan, the comments on the study plan, and the response comments on the study plan were included in the study report for the February 1993 coral reef survey (CH2M HILL, 1993).

The first required study under the NPDES permit was conducted in February 1993 and reviewed by USEPA and ASEPA. One comment was received on the 1993 study, which is discussed in the description of study approach below. During the 1995 study no substantial recommended changes to the study plan were identified for future surveys, although CH2M HILL did recommend that positioning be done using an appropriate global positioning system (GPS) rather than a MiniRanger system. The last survey conducted prior to the one described in this report was in March 2002.

The current NPDES permit condition states that coral reef surveys shall be conducted at four of the same sites surveyed during the 1991 *Use Attainability Analysis* (CH2M HILL, 1991) to detect significant differences, if any, from the 1991 baseline reef survey data. These four stations are the closest stations to the present discharge of the Canneries through the Joint Cannery Outfall (JCO). The wastewater discharge locations and methods for the canneries have changed between the 1991 survey and the initiation of surveys required under the previous NPDES permit condition. This change in discharge locations has had an effect on improving receiving water conditions throughout the Harbor.

In January 1991, when the baseline reef survey study was conducted, the two canneries operated separate wastewater outfalls in the inner Harbor area of Pago Pago Harbor. Currently, Star-Kist Samoa and COS Samoa Packing operate the JCO that extends over 7,000 feet west from the canneries to a deep-water site offshore of Anasosopo Point in the outer Harbor. The outfall consists of a 16-inch HDPE pipe that terminates with a multiport diffuser at a depth of 176 feet below mean lower low water (MLLW). The outfall pipeline route and diffuser location are shown in Figure 1-1. In addition to relocating the discharge in February of 1992, the canneries began high strength waste segregation in August of 1990. Since that time cooker juice, press liquor, and DAF sludge have been disposed of at an EPA-approved ocean disposal site.



The January 1991, February 1993, March 1995, March 1997, March 2002, and March 2005 surveys involved recording reef transects at multiple-depths along the reef fronts at sites located around the entire perimeter of Pago Pago Harbor. The coral reef field surveys were designed to provide comparable records of the reef conditions throughout the Harbor for use in an evaluation of reef-face habitat conditions in areas of the inner, middle, and outer Pago Pago Harbor. These surveys were designed to provide a semi-quantitative summary of reef corals and other benthic species. Reef fish identifications were incidental.

1.3 Study Site Description

The American Samoa Coral Reef Inventory (published by the U.S. Army Corps of Engineers in 1981), reports that the fringing coral reefs in Pago Pago Harbor have been extensively modified, primarily by the U.S. Navy and American Samoan Government. Dredging, filling, construction of rock seawalls and other structures for roadway slope stabilization, and other construction activities have resulted in physical alterations to the coral reefs. These activities began around 1900. The most dramatic changes occurred during World War II and since 1960. The Coral Reef Inventory reports that approximately 23-percent of the original reef flat area in Pago Pago Harbor has been filled.

The inner Harbor area has been the most affected by development activities. According to the Coral Reef Inventory, 95 percent of the original reef in the Inner Harbor has been converted to dry land. Some remnant reef is found in the inner Harbor area but living corals have been absent from the inner Harbor for many years. This conclusion, presented in the Coral Reef Inventory, was drawn from a 1977 study.

Substantial physical alterations to the reef in the Middle and Outer Harbor include the following as presented in the Coral Reef Inventory:

- The reef flat off the Rainmaker Hotel and Utulei Beach has been dredged to provide sandy areas for swimming and access across the reef.
- Near Aua Point, a borrow pit 18 feet deep was dredged to obtain roadbed fill material, creating a large lagoon inside the inner reef.
- The shoreline north of Tafagamanu Point was extended 300 feet onto the reef flat by filling for a sanitary landfill.
- An extensive fill area along the south Fagaalu Bay was developed for a public park from material dredged from the reef flat.
- The discharge of sediments from the streams draining into the Harbor has led to
 extensive siltation over large portions of the reef near the mouths of these
 streams (described in detail below).

The coral reefs of American Samoa have been subjected to periodic infestations or population explosions of the coral-feeding crown-of-thorns starfish (*Acanthaster planci*).

The 1981 Coral Reef Inventory reported serious crown-of-thorns infestations on the reefs of Tutuila Island in the 1920s and most recently in the late 1970s and early 1980s. These periodic infestations have greatly reduced the live coral assemblages on the fringing reefs. Destruction of the live coral assemblages has been shown to vary widely, but, as described in the Coral Reef Inventory, roughly 50 to 95 percent of live coral were estimated to have been destroyed by the 1970-80 starfish infestation.

Recent dive surveys of the coral reefs in the Fagatele Bay Marine Sanctuary have shown live coral coverages of approximately 50 percent after nearly complete destruction by the crown-of-thorns starfish. The fringing reefs of middle and outer Pago Pago Harbor were also substantially damaged by the crown-of-thorns infestation. The starfish were observed on the reefs off Aua (in middle Harbor) and of Fagaalu (outer Harbor) during 1980 when the Coral Reef Inventory was conducted. Reef recovery from these infestations is slow, and the existing live coral coverages on the fringing reefs of Tutuila Island still show large areas of dead coral.

Periodic hurricanes pass near or directly over Tutuila Island, and these storms generate large waves. Waves approaching from the south enter the outer and middle Harbor and break on fringing reef, damaging the reef habitat either directly or by disturbing sediments that are deposited on the reefs. Recent intense hurricanes, particularly Hurricane Fay, have had significant impacts on the fringing reefs in Pago Pago Harbor through wave impacts, siltation, and longline vessels grounded on the reefs. In addition, until recently, much of the roadbed abutting the reef flat was unprotected from erosion through riprap cover or other stabilization techniques, leading to extensive siltation of some areas of the reef flats. In recent years erosion protection along portions of the roadway has been substantially improved. Any effects of hurricane Heta of 2004 should be reflected in changes between the 2002 survey and the 2005 survey described in this report.

Potential impacts from cannery, and other point source, discharges include direct sedimentation on the reef, reduced water clarity because of sediments, and high algal productivity resulting from nutrient inputs. Affects on coral reef communities appear to have been substantially eliminated with the implementation of high strength waste stream segregation and the relocation of the outfall diffuser to water depths of more than 170 feet in the outer Harbor.

Dye studies conducted by CH2M HILL (1992, 1993) as a condition of the NPDES permit indicate that the plume typically remains trapped in the lower part of the water column. Under certain meteorological and oceanographic conditions the plume rises further but is typically diluted to more than 2000:1 it the edge of the permitted mixing zone and does not impact the nearby coral reefs.

Harbor water quality monitoring conducted in March 1995, March 1996, November 1996, March 1997, and more recently in 2001, 2002, 2003, 2004, and 2005 as a condition of the NPDES permit, indicates that nutrient levels have fallen below the American Samoa water quality standards (ASWQS) and phytoplankton levels have similarly fallen (see

reports listed in references in Section 4). The same studies have indicated that light penetration also meets the ASWQS.

1.4 Approach

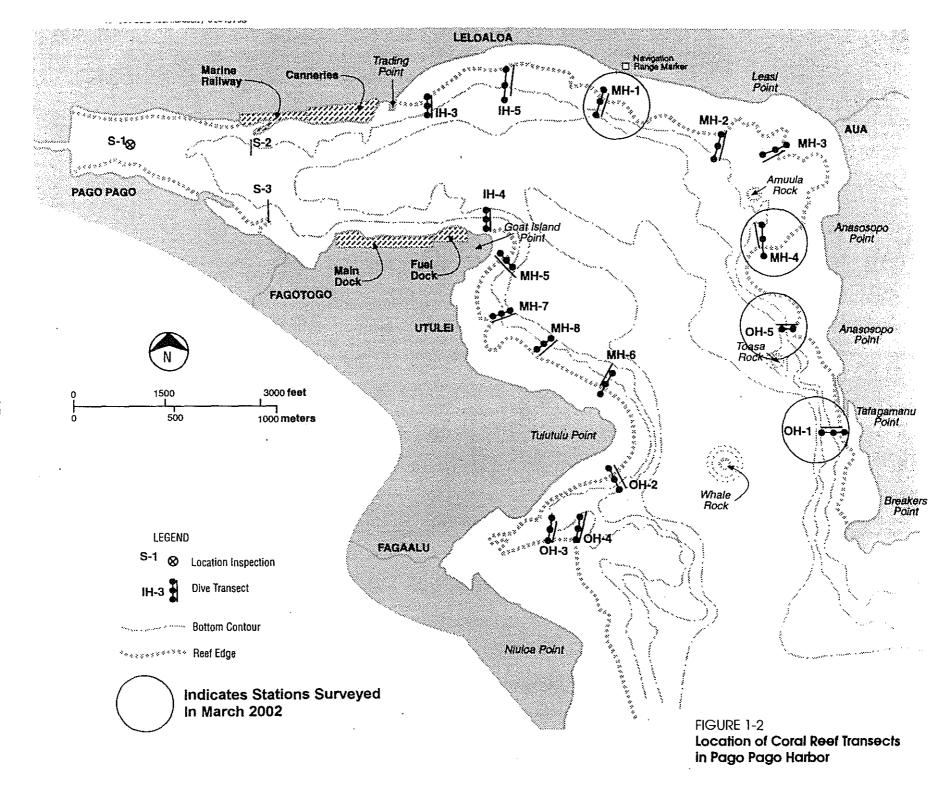
The approach and methodology for the coral reef survey has been designed, to the extent feasible, to maintain consistency between the periodic studies, and to be consistent with available guidance provided in the *Design of 301(h) Monitoring Programs for Municipal Wastewater Discharges to Marine Waters* (USEPA, November, 1982). To meet the NPDES permit conditions, video transects were recorded at multiple depths at each of the four established reef transect sites around Pago Pago Harbor (Figure 1-2). Detailed methodology is presented in Sections 2 and 3 below.

The coral reef field survey described in this report was conducted to provide video transect records of the reef conditions in the areas adjacent to the canneries discharge that can be compared with the 1991, 1993, 1995, 1997, 2002 surveys and with future surveys at the same locations. These surveys can be used to evaluate the condition of, and changes to, the reef-face habitat in areas of interest. The surveys are limited to providing semi-quantitative data on the type and percent cover of live reef corals and other benthic species. Reef fish identifications are incidental to the reef habitat evaluation.

1.5 Scope and Limitations

The intent of the study is to monitor long term overall changes in the various portions of the Harbor. Since video records at the start and end of the transect locations are at fixed points, and additionally the video transect record includes scale by including the tape measure placed on the bottom, both fixed and random locations of known area can be derived from the video record if desired. However, the analysis presented in this report is intended to be a monitoring or screening level exercise to detect the onset of significant changes in the Harbor. If such changes are detected, and are considered potential adverse impacts, additional work may be required to assess the significance and causes of such changes.

The video transect records were analyzed and summarized by Mr. Troy Buckley of the University of Washington School of Fisheries. Mr. Buckley is a qualified marine ecologist with knowledge of tropical reef taxonomy and several years of site-specific experience in American Samoa. He also analyzed the 1991, 1993, 1995, 1997, and 2002 survey videos. Estimates were developed of live coral coverage and specific benthic genera identifications were provided, as feasible, from the video record. Field survey data are presented in tabular formats in the results section of this report. Supporting data are included in Appendix A. Copies of the video records are provided to ASEPA and USEPA as separate attachments to this report.



2. FIELD SURVEY METHODS

This section describes the methods and equipment used for the coral reef surveys, including horizontal positioning at each reef site, sampling methods, and QA/QC procedures. The same divers that conducted the previous surveys did the 2005 survey.

2.1 Field Equipment

Field equipment requirements for the reef surveys are listed in Table 2-1. A small work vessel was used for the surveys. A three-person staff was aboard to conduct the reef survey transects. Two divers conducted the surveys, with a third person assigned as a boat handler and support.

	Table 2-1								
Field Equipment for Coral Reef Surveys									
Equipment Item	Purpose	Number of Units							
Work Vessel	Field Sampling Platform	1							
SCUBA diving equipment and tanks	Underwater surveys	5							
Dive Computer	Continuous dive logging for each diver's repetitive dives and surface intervals (safety equipment)	2							
Sony 8mm Video camera w/ underwater housing and lights	Underwater videotaping of reef transects	2							
Sony 8mm Videotape player	Viewing and verification of videotape records	1							
100 feet fiberglass tape measure	Provide reference line for video transects	1							
Transect Stakes	Re-establish start and end point for any missing stakes	10							
Depth Gage	Verify transect depths	2							
GPS System	Global Positioning System	1							

2.2 Survey Sites and Field Positioning

Four reef sites were surveyed in March 2002 (Figure 1-2). Multiple transects were conducted at three depths at each of these sites. The four reef survey sites were located based on the descriptions in the 1991 Use Attainability Analysis reef survey logbook and photographs of the reef and shoreline at each site. The horizontal position of each site was established in February 1993 using a Motorola Mini-Ranger III electronic positioning system. The Mini-Ranger III provides positioning range accuracy of approximately ±2 meters. The previously established Mini-Ranger locations of each site and the site descriptions are given in Table 2-2.

Table 2-2 Transect Locations for Coral Reef Survey Pago Pago Harbor Established During February 1993 Survey {Indicated Transects Re-established During March 1995 Survey}									
Station	Coordi MiniRang (a	gation nates for jer System i,b)							
		Code 1	Code 4						
MH-1	Middle Harbor, located off Harbor front range marker (Code 1), Transects at 25, 40, and 60 feet	216 (S)	1198 (S)						
MH-4	Middle Harbor, located on north face of reef and west of Aua Point, Transects at 25, 40, and 60 feet	1082 (S) 1649 (S							
OH-1	Outer Harbor, located on west face of reef off Tafagamanu Point, Transects at 25, 40, and 60 feet	2033 (S) {1954 (S)}	2166 (S) {2154 (S)}						
OH-5	Outer Harbor, located on west face of reef off Anasosopo	1466 (S)	1799 (S)						

(a) The shore-based Mini-Ranger transponders were located at survey control points as follows: Code 1 - located at Pago Pago Harbor Front Range Tower (261,551.58E and 309,857.04N, State Coordinates (feet));

{1646 (S)}

{1992(S)}

- Code 4 located at Fagatogo Tram Park Building (258,117.06E and 305,879.24N, State Coordinates (feet)).
- (b) The navigation readings are designated as either north (N) or south (S) of the alignment between the Code 1 and Code 4 shore transponder stations.

Point, Transects at 25, 40, and 60 feet

Each of the four sites was relocated in 2005 by means of the transect marker stakes placed in 1993 (or as replaced in 1995 or 1997) at the start of each transect. Transect marker stakes were relocated by visual positioning and GPS positioning. Markers at some of the transects were degraded or missing and were replaced. However, sufficient markers were recovered at all locations to provide a high degree of confidence that the same transects were filmed as in the previous surveys. A buoy was deployed to assist divers to search for the stakes when not immediately recovered.

2.3 Reef Transect Methods

OH-5

Marine biologist-divers recorded underwater video transects on the reef front at the four sites in Pago Pago Harbor (Figure 1-2). Video transects were recorded along the reef face at three depths. Each video transect was conducted parallel with the reef face (along a constant depth contour) along a 30-meter fixed transect line on the reef. The depths at which video transects were recorded included: the reef edge (15- to 20-foot depth), on the reef face (at 30- to 40-foot depth), and near the base of the reef face (at 55- to 65-foot depth).

One diver maintained position along the transect stake location and handled a 100-foot tape measure (also marked in meters). The other diver swam slowly along the established 30-meter transect line with the video camera. At the completion of the transect filming, the transect line was picked up and moved to the next transect depth and the procedure was repeated.

A field logbook was maintained and included: the sampling dates and times, descriptions of the site, transect depths, reef face structure and features, reef biota observations, and weather and sea conditions. The videotape was reviewed at the completion of each day in the field to ensure that the record is complete and to verify the location of each transect record on the video tape.

2.4 Quality Assurance and Quality Control

The quality assurance and quality control objectives for the coral reef surveys are to record representative reef-front transects at each site and provide scientific interpretations and summaries of these reef transect videos that are of known and acceptable quality. The following requirements were instituted for the field data collection to meet the objectives.

- Re-establish long-term transect markers and document survey site positions (within 2 meters) for repeat surveys.
- Provide field equipment redundancy (backup equipment).
- Review and revise, as necessary, field operations and safety plan for conducting the
 reef surveys to summarize the schedule, survey procedures, field data recording,
 and safety procedures. This operations and safety plan is a key element of quality
 assurance and control activities.
- Test all dive and photographic equipment onsite prior to the beginning of the surveys and conduct daily equipment checks.

In addition, the data analysis, described below in Section 3, was accomplished in a manner to provide verifiable photographic interpretations of the reef transect videos. Portions of video transects were reanalyzed to verify transcription accuracy.

3. Data Analysis and Presentation of Results

The field surveys of the fringing coral reef in Pago Pago Harbor were conducted March 1-4, 2005. The coral reef surveys are used to evaluate the condition of, and changes to, the reefface habitat in Pago Pago Harbor in the vicinity of the JCO. The surveys are limited to providing semi-quantitative data on the type and percent cover of live reef corals and other benthic species. The intent of the surveys is to provide information necessary to generally characterize and document changes to the reef habitat. It is not intended that the data be used to quantitatively describe details of the reef habitat or communities. The surveys are targeted at examination of the benthic substrate and species. Reef fish identifications are not an objective of the study.

3.1 Analysis of Video Tapes

The videotape transect records were analyzed and summarized by a qualified marine ecologist with tropical reef knowledge and several years of experience specifically in American Samoa. The videotape analysis involves repeated slow-frame viewing of the transect video to record estimates of live coral coverage and specific benthic genera. The percent of live coral was estimated at 5 meter intervals along the transect line, for a minimum of 2.5 meter segments. In most cases the entire 5-meter interval was used for the estimates. Benthic genera identifications were made, as feasible, from the video record. Field survey data was then summarized from notes made during the video transect viewing.

Using mobile species like fish to assess ecological impacts or habitat quality on a relatively small scale is not feasible without conducting the survey over a long period of time. Many environmental and behavioral factors (season, lunar phase, time of day, tide, weather patterns, etc.) may influence the abundance of fish species in a given area at a given time. Using the sessile benthic community (primarily scleractinian corals) and habitat complexity and structure to assess the prevailing or average ecological condition introduces the least amount of bias due to immediate conditions and diver avoidance.

Data collection with video tapes of prescribed areas, or transects, reduces the limitation of SCUBA diver bottom time. However, some detail will be lost and some bias will be introduced by the camera and the camera operator. Use of video transects in this case reduced the ability to detect and distinguish between encrusting corals, coralline algae, sponges and other organisms. Camera operator bias can be introduced in several ways; traveling speed and distance from bottom, camera angle, straying from transect, recognition of organisms requiring closer focus to be identified by the video tape reviewer, and in some cases, not providing scale with the transect line as a reference.

Translation of the video tape records into semi-quantitative data required identifications, and estimations of sizes and percentage of area covered, to the extent possible by viewing the tapes. Coral identification is only provided to the generic level. Levels of uncertainty vary and depend on colony size and shape and the uniqueness of the colony form to certain

genera (for example *Echinopora* and *Montipora* are easily confused by video inspection). Distance, angle and form of the colony can cause errors in estimating size and areal coverage. This is compounded by the inability to distinguish between encrusting organisms.

Although there are biases unavoidably introduced in a survey such as the one reported here, gross identification of the larger benthic organisms, including corals, and a general characterization of the habitat structure and complexity were achieved. Biological interpretations and projections of the results are difficult, and are especially vulnerable to an individual's predicated bias. However, for the purpose of detecting general habitat changes over long time periods the techniques used in this survey are acceptable and adequate to achieve the objectives of the NPDES permit condition.

3.2 Reef Survey Results

The transect analyses notes are presented in Appendix A. Table 3-1 summarizes the semi-quantitative survey results. The summary table provides the station characteristics, benthic or sessile organisms coverage, and hard coral coverage for each transect. Copies of the video records are provided to ASEPA and USEPA as a separate attachment to this report.

Station MH-1

Station MH-1 is located along the northern shore that receives direct wave impacts from the south. The transects conducted at this station had 17 percent live coral coverage at the 25-foot transect depth, compared to 78 percent for the 2002 survey and 36 percent in the 1997 survey. The earlier surveys had considerably less than 17 percent coverage. The 40-foot depth had coverage of hard coral of 48 percent compared to 50 percent for the 2002 survey and 22 percent in 1997. The highest coverage at this station was 55 percent at the 60-foot depth compared to 32 percent for the 2002 survey and 8 percent in 1997. Coverage in previous surveys (1995, 1993, and 1991) was lower than the 1997 survey percent cover values.

The severe impacts of Tropical Cyclone Val in December 1991, Tropical Cyclone Ofa, in February of 1990, and Tropical Cyclone Lin in February of 1993 were evident in previous surveys. For example, in the 1993 survey the 25- and 40-foot transects at this station showed much higher sand/silts and rubble coverage, which represented a substantial increase over the 1991 values. Evidence of the hurricane wave forces is exhibited by the six longline vessels that were grounded on the reef flats between Leloaloa and the harbor navigation range marker (site of MH-1). The reduction in the coverage at the 25-foot contour observed during the 2005 survey may have been a result of hurricane Heta (January 4 and 5 2004) combined with activities associated with the removal of the grounded long liners (2000).

Station MH4

The results of the reef survey at MH-4, located inside the semi-enclosed embayment between Leasi Point and Aua Point, show moderately diverse coral representation. The 25-foot transect at these stations had 21 percent live coral compared to 35 percent during the 2002 survey, 28 percent live coral in the 1997 survey, and 20 percent in the 1993 survey. In this survey (March 2005) the coverage of the bottom with sand/silt and rubble at MH-4 remained similar or possibly somewhat higher than for the 2002 survey.

Station	T			·	MH-4	Sur	T ,	011			O11 -	
	Stati	MH-1		L aristic		·	L	OH-1		L	OH-5)
Depth (ft)	25	40	60	25	40	60	25	40	60	25	40	
Percent Sand, Sediment & Rubble	 ~~	1	10	35	48	92	2	12	70	 23	<5	
Refuse (x = refuse noted)	l x	x	10	X	X	X	 -	12	70	 	-3	H
Slope Description	FS	T/S	T/G	T/S	T/S	Ĝ	w	W	FS	W W	FS	╁
Sessile	1						VV		13	VV	ГО	<u></u>
Algae	T 3	2	, their	1	1	1901	r	<1	1		<1	Τ.
Calcareous algae	╁∸	-	<1		<u> </u>		 -			<1	 `	H
Coralline algae	50P	35P		8P	4P		35P	38P	9P	52P	30P	13
Encrusting ascidians	10p	7P	3P	5P	2P	 	15P			10P		
Encrusting sponges	11P	6P	5P	18P	1P		15P	10P	9P	10P	10P	1
Sponges	6	2	1	6	2	2	3	2	1	2	4	Γ'
Unidentified epiphytes	Ť	1P	P	┝┈	_	_	Ť		- '-		-	1-
Hydroids	1		<1	<1	····			<1		-		1
Bryozoan	1	 	<1	'- -	 							Γ,
Styllaster (hydrocorallina)	1				ļ <u>.</u>	_						
Millepora (hydrocorallina)	3		2		 		6			2		-
Zoanthids	۲Ť		1				<u> </u>					-
Soft coral	1		<u> </u>	4	8	1	· · · · · · ·					-
Gorgonian	1							<1P				-
Other Organisms	 			<1	<1							_
	rd Cor	al (ne	rcent				L				· · · · · ·	
Pocillopora	4	2			-3-1		· · · · · ·		""]	5	<1	_
Montipora	8	30P	28	4	4P	1P	20P	12	<1P	10	25	3
Acropora	1	3	-20		71	15"	ZUP		715	<1 <1	<u> 25</u>	H
-ungia			1		<1		 			\	<1	
Porites	2	10P	15	2	- `-		4P	3	<1P	3	4	2
Soniopora or Alveopora	 	, 51							·IF	~	-	_
aviidae		<1					\vdash			<1	3	-
Diploastrea heliopora	2	P		14	26	1				<1		<
Salaxea												1
eptoseris			10P	1P								
obophyllia			· · - ·		<1	<1	$\neg \neg$					
/lerulina					1P					$\neg \uparrow$		
Pachyseris			<1									
Cyphastrea		<1P									\dashv	_
chinopora		1P	\neg			2P		6	_		5	
Oxypora								-		$\neg \neg$		
Coscinarea										 		
sammocora						-		 1				
Sammocora												
Seriatopora												
		ĺ			ſ			ı	1			
eriatopora								<1				
eriatopora Pavona Istreopora								<1		_		
eriatopora Pavona Istreopora Urbinaria (or Mycedium)								<1				
eriatopora Pavona streopora urbinaria (or Mycedium) Inidentified Encrusting Forms	17	48	55	21	33	5	24		2	22	40	•
eriatopora Pavona Istreopora Urbinaria (or Mycedium)	17 5	48 7	55 5	21 4	33 5	5 4	24	<1 22 4	2 2	22 7	40	- 6

Station OH-1

The percentages of live corals on the steep reef face structure at Station OH-1 was generally similar to the previous survey results except for an apparent decrease in the coverage for the shallower transect (25-foot contour). The 2005, 2002 and 1997 surveys showed similar conditions to the 1993 and 1995 surveys, and were substantially greater than the previous surveys at the 40-foot and 60-foot contours. Silt coverage, and benthic diversity observed at Station OH-1 was comparable to the reef face conditions during 2002 and 1997. Wave conditions are more intense at this station than the others surveyed, and the reduced coverage at 25 feet may have been a result of damage by hurricane Heta.

Station OH-5

The transect conducted at 25- and 40-feet at Station OH-5 consists primarily of a steep slope of staghorn coral (*Acropora*) rubble with coralline algae and encrusting sponges and ascidians on the rubble. The total percent live hard coral at OH-5 was greater in 2002 than in 1997 at all depths. However, in 2005 the coverage at the shallow transect was reduced, very much like that for Station OH-1 and potentially for the same reason. Visual observations in 1991 and 1993 showed that this reef face displayed indications of typical wave damage down to 50 feet depth.

The sand/silt and rubble coverage at these two transect depths was much improved in 1997 from previous surveys, and improved even further at the 60 foot depth in 2002. However in 2005 the amount of sediment (sand and silt over coral rubble) at the 60-foot contour was considerable elevated. Station OH-5 is located approximately 600 feet from the JCO diffuser. No evidence of the wastewater impacts was evident and with the exception of the decrease in coverage at the shallow depths the coverage appears to be improving significantly over time at the deeper transects. The percent coverage at the 40 foot contour has monotonically increased for every survey form 5% in 1991 to 40 percent in 2005.

3.3 Discussion of Results

This report presents the results of the coral reef survey conducted to monitor possible changes in reef conditions following relocation of the canneries discharge points and the implementation of high strength waste segregation. These coral reef field surveys were also designed and conducted to allow comparisons of the reef conditions over time. Previous coral reef survey reports also provided comparisons between regions in the harbor.

A general qualitative comparison can be made between this survey (2005) and the previous surveys done by CH2M HILL in 1991, 1993, 1995, 1997, and 2002. The results of this comparison are summarized in Table 3-2. Table 3-2 attempts to provide an overall synthesis by examination of the total percent covered by hard coral at all depths combined, and the total number of genera identified. The summary of results includes the following points:

 All of the stations show apparent improvement over time in terms of percent hard coral coverage from 1991 to 2002 and are still improving or stabilizing based on the most recent data. This recent trend is somewhat confused, probably because of the effects of hurricane Heta.

Summany Desults of the 2005 2002 4007 4005 4000 ==== 14004											
Summary Results of the 2005, 2002, 1997, 1995, 1993 and 1991 Coral Reef Surveys											
Station	MH1	MH4	OH1	OH5 ^A							
March 2005 Survey											
Total Percent Live Hard Coral Coverage (depth average)	40	20	16	31							
Total Number of Live Hard Coral Genera Identified per Station (all depths)	11	8	4	7							
March 2002 Survey											
Total Percent Live Hard Coral Coverage (depth average)	52	25	21	36							
Total Number of Live Hard Coral Genera Identified per Station (all depths)	11	5	6	8							
March 1997 Survey											
Total Percent Live Hard Coral Coverage (depth average)	22	22	15	18							
Total Number of Live Hard Coral Genera Identified per Station (all depths)	9	6	6	5							
	March 1995 Sเ	ırvey									
Total Percent Live Hard Coral Coverage (depth average)	9	33	20	21							
Total Number of Live Hard Coral Genera Identified per Station (all depths)	5	8	5	6							
	February 1993 S	Survey									
Total Percent Live Hard Coral Coverage (depth average)	11	15	13	6							
Total Number of Live Hard Coral Genera Identified per Station (all depths)	5	4	6	4							
	January 1991 S	urvey									
Total Percent Live Hard Coral Coverage (depth average)	13	20	8	8							
Total Number of Live Hard Coral Genera Identified per Station (all depths)	4	7	4	7							

Table 3-2

^A The 60 foot depth data removed from OH-5 to make results comparable with the 1991 survey. With the 60 foot data included the percentage cover of hard coral becomes 23% and the number of genera becomes 8 for the 2005 Survey.

- Station MH-1 also appears to show a trend towards higher diversity in terms of total number of genera.
- Station MH-4 does not indicate as clear a trend of improvement, but there is no
 indication of degradation. This station appears to be affected by sediment loads
 from the nearby stream that runs through the village of Aua, and this is reflected in
 the observation that the percent sand and silt is typically substantially higher than
 for the other stations.
- Station OH-5, closest to the JCO discharge appears to be improving, although possible compromised by recent hurricane effects, and no effect of the discharge is discernable.

Table 3-3 provides a more detailed compassion than discussed above for total percent live hard coral and the total number of hard coral genera for all the studies by transect and depth. Differences in details such as variability with depth of actual numbers and genera, and other station characteristics, can be examined by comparing Table 3-1 with previous results in the reports for the 2002, 1997, 1995, 1993, and 1991 surveys.

Table 3-3												
Summary Results of the Coral Reef Survey Transects												
by Depth for Stations Occupied in 2005 Station MH1 MH4 OH1 OH5												
Depth (ft) for all Surveys Except		T	l	 		 		OH1	T	├	OH5	T.
1991	25	40	60	25	40	60	25	40	60	25	40	60
March 2002 Survey												
Total Percent Live Hard Coral	17	48	55	21	33	5	24	22	2	22	40	6
Total Number of Hard Coral Genera	5	7	5	4	5	4	2	4	2	7	7	3
March 2002 Survey												
Total Percent Live Hard Coral	78	50	32	35	30	11	34	25	3	40	31	5
Total Number of Hard Coral Genera	6	6	6	3	3	2	4	4	2	5	5	2
March 1997 Survey												
Total Percent Live Hard Coral	35	22	8	28	31	7	24	16	4	21	15	1
Total Number of Hard Coral Genera	6	5	5	5	2	2	4	3	2	5	3	0
	M	larch	1995	Surv	ey		数 多 的。 3 包 数	121 (1) 121 (1) (1)			lisadini Andra	
Total Percent Live Hard Coral	7	15	5	25	26	3	34	25	0	29	12	1
Total Number of Hard Coral Genera	3	3	4	3	2	2	4	3	0	6	2	0
	Fel	oruar	y 199	3 Suı	vey	ing die				for the		
Total Percent Live Hard Coral	20	<9	<5	20	30	0	27	7	<5	5	7	4
Total Number of Hard Coral Genera	2	4	0	1	1	0	5	2	0	2	4	2
January 1991 Survey												
Total Percent Live Hard Coral	<1	>30	>8	10	50	0	10	<5	<10	10	5	
Total Number of Hard Coral Genera	1	3	3	1	1	0	3	2	3	4	4	
Depth (ft) for January 1991 Study	20	35	55	15	40	60	20	35	60	30	50	

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APPENDIX A CORAL REEF TRANSECT ANALYSIS FIELD SURVEYS CONDUCTED 1-4 MARCH 2005

TRANSECT SUMMARIES

FIELD SURVEYS CONDUCTED BY CH2M HILL, 1-4 MARCH 2005

Video Interpretation by Troy Buckley

Descriptions of each transect include estimates of the percent areal coverage, summarized over the entire transect, by substrate type and by distinguishable types of biota. These transect summaries are presented from inner to middle to outer Pago Pago Harbor. Stations are presented in numerical order within each section of the harbor.

MIDDLE HARBOR: Station MH-1 Transects

25-Foot Depth (MH-1)

At a depth of 25 feet, the habitat was composed of a variety of complex coral formations affording a wide size-range of caves, crevices and holes. Some loosely coiled, encrusted rope or cable was seen near the end of the transect. The substrate was silt-free (0%) and sponges (6%) were very numerous. Small patches of possibly feathery red algae (1%) and filamentous green algae (2%) occurred. Encrusting organisms probably included coralline algae (maybe 50%), sponges (maybe 11%) and ascidians (maybe 10%). The non-scleractinian, stinging coral, *Millepora* (3%), encrusted some surfaces. Scleractinian corals were represented primarily by encrusting colonies of *Montipora* (8%) and *Porites* (2%), but small colonies of *Pocillopora* (4%) were common, and a colony of *Diploastrea heliopora* (2%) and a colony of delicately branching *Acropora* (1%) also occurred. A large colony of *Diploastrea heliopora* was seen just below the transect. Fishes were plentiful in the area of this transect and they included farmerfish (*Stegastes* sp. - pomacentridae), blue devil (*Chrysiptera cyanea* - pomacentridae), angelfishes (pomacanthidae), butterflyfishes (chaetodontidae), surgeonfishes (acanthuridae), wrasses (labridae) and parrotfishes (scaridae).

40-Foot Depth (MH-1)

At a depth of 40 feet, the habitat was moderately complex, dominated by remnant shelves and terraced coral formations, but the transect crossed less complex areas of limestone boulders and low pockets of rubble. Silt (1%) was rare and appeared to be consolidated by epiphytes (probably hydroids and algae) and two encrusted ropes crossed near the end of the transect. Some solid surfaces were encrusted by coralline algae (maybe 35%), encrusting sponges (maybe 6%), ascidians (maybe 7%) and other epiphytes (1%). A few small, standing sponges (2%) and patches of filamentous green algae (2%) were seen. Scleractinian corals were dominated by encrusting and laminar colonies of *Montipora* (maybe 30%), *Porites* (maybe 10%) and *Echinopora* (maybe 1%), but massive and possibly table *Acropora* (3%) colonies occurred, as did small colonies of *Pocillopora* (2%), unidentified faviid (<1%), and possibly *Cyphastrea* (<1%). Fishes seen near the transect included surgeonfishes (acanthuridae), goatfishes (mullidae), bluestreak cleaner wrasse (*Labroides dimidiatus* - labridae), and several damselfishes (pomacentridae) including farmerfish (*Stegastes* sp.), princess damsel (*Pomacentrus vaiuli*) and jewel

damsel (*Plectoglyphidodon lacrymatus*). A colony of *Diploastrea heliopora*, about one meter in diameter, was seen just below the transect.

60-Foot Depth (MH-1)

At a depth of about 60 feet, the habitat had a variety of complexity, alternating among complex remnant formation, slopes of terraced plates and shields, and coral rubble. Silt cover (10%) was light on solid surfaces but more concentrated in low areas with rubble. especially near the end of the transect. Some of the silt appeared to be consolidated by epiphytes (including algae and hydroids), and small patches of calcareous algae, probably Halimeda (<1%), hydroids (<1%), and a feathery bryozoan (<1%) were seen. A few small sponges (1%), encrusting sponges (maybe 5%), encrusting coralline algae (maybe 20%), and encrusting ascidians (maybe 3%) occurred throughout the transect. Zoanthids (1%) occurred near the end of the transect and the non-scleractinian, stinging coral. Millepora (2%), encrusted some surfaces. Scleractinian corals were dominated by encrusting and laminar plate forms of Montipora (28%), Porites (15%) and possibly Leptoseris (10%), but Fungia (1%) and Pachyseris (<1%) were also seen. It appeared that digitate Acropora occurred just next to the transect. Fishes seen near the transect included surgeonfishes (acanthuridae), damselfishes (pomacentridae), regal angelfish (Pygoplites diacanthus - pomacanthidae), butterflyfish (Chaetodon sp. - chaetodontidae) and long-finned bannerfish (Heniochus acuminatus - chaetodontidae).

MIDDLE HARBOR: Station MH-4 Transects

25-Foot Depth (MH-4)

At a depth of 25 feet, the transect crosses over complex coral formations, rubble channels and large *Diploastrea heliopora* shields, and crosses under large overhangs, all contributing to a variety of habitat complexity. Silt (35%) coverage was common but varied, perhaps consolidated by hydroids (<1%) in a few places, and a beverage bottle was seen on the transect. Sponges (6%) and a fleshy red algae (1%) were common throughout, and a calcareous bush-like structure that may have been tubes of colonial polychaete worms (<1%) (like *Filogramma implexa*) or a calcareous red algae was seen. Encrusting organisms included coralline algae (maybe 8%), encrusting sponges (maybe 18%) and ascidians (maybe 5%). Soft coral (alcyonacea) (4%) was noted on the latter half of the transect. Scleractinian corals were dominated by *Diploastrea heliopora* (14%) shields, but encrusting and laminar plate forms of *Montipora* (4%), *Porites* (2%) and possibly *Leptoseris* (1%) seemed dispersed throughout the transect. Fishes in the area of the transect were triggerfish (balistidae) and damselfishes (pomacentridae) including farmerfish (*Stegastes* sp.), princess damsel (*Pomacentrus vaiuli*) and blue devil (*Chrysiptera cyanea*).

40-Foot Depth (MH-4)

At a depth of 40 feet, the habitat was moderately complex with some consolidated coral formations above a rubble and silt bottom. Overall, sand and silt (48%) covered rubble and many solid surfaces, and a beverage can and bottle and two fishing lines were seen. Encrusting organisms probably included coralline algae (maybe 4%), encrusting sponges

(maybe 1%) and ascidians (maybe 2%). Sponges (2%), calcareous bush-like structures that may have been tubes of colonial polychaete worms (<1%) (like Filogramma implexa), and algae (1%) occurred. Colonies of soft corals (alcyonacea) (8%) were conspicuous. Scleractinian corals were dominated by large colonies of Diploastrea heliopora (26%), but Fungia (<1%), Lobophyllia (<1%) and encrusting and laminar corals including Montipora (maybe 4%) and possibly Merulina (1%) also occurred. Regal angelfish (Pygoplites diacanthus - pomacanthidae), vagabond butterflyfish (Chaetodon vagabundus - chaetodontidae), poison-fang blenny (Meiacanthus atrodorsalis - blenniidae), and surgeonfish (acanthuridae) were seen swimming in the area of the transect. A large hawksbill turtle (Eretmochelys imbricata) was seen nearby.

60-Foot Depth (MH-4)

At a depth of 60 feet, the habitat was dominated by accumulated rubble and silt from the reef slope above that settled around and under large remnant shields of *Diploastrea heliopora* on a gently sloping bottom. Silt (92%) covered a majority of the rubble and solid substrate, and fishing lines, a beverage can and a spout from a pump bottle occurred on the transect. The silt appeared to be consolidated by epiphytes (probably hydroids and algae) in places. A few sponges (2%) and a colony of soft coral (alcyonacea) (1%) were present. Living scleractinian coral was minimal and included *Diploastrea heliopora* (1%), *Lobophyllia* (<1%), several small encrusting and laminar colonies that were probably *Echinopora* (maybe 2%) and *Montipora* (maybe 1%). Fishes in this area included damselfishes (pomacentridae), butterflyfish (*Chaetodon* sp. - chaetodontidae), triggerfish (balistidae), and clown wrasses (*Coris gaimard* - labridae).

OUTER HARBOR: Station OH-1 Transects

25-Foot Depth (OH-1)

At a depth of 25 feet, caves and overhangs gave the nearly vertical habitat some complexity over most of the transect, but near the beginning of the transect, it was not as steep, and a pocket of silt and a pocket of rubble occurred. The video record of this transect appeared out of focus. A large, 5 x 5 meter, colony of *Diploastrea heliopora* was seen near the transect. Silt (2%) was minimal and the solid substrate appeared encrusted with coralline algae (maybe 35%), probably encrusting sponges (15%), and ascidians (15%). Sponges (3%) were seen throughout the transect, and the non-scleractinian, stinging coral, *Millepora* (6%), appeared to encrust some surfaces. Encrusting scleractinian corals were common and probably included *Montipora* (20%) and *Porites* (4%). Many fishes were seen in the area of the transect including damselfishes (pomacentridae) - sergeants (*Abudefduf* sp.) and farmerfish (*Stegastes* sp.); surgeonfishes (acanthuridae) - surgeonfish (*Acanthurus* sp.) and bristle-toothed tangs (*Ctenochaetus striatus*); butterflyfishes (chaetodontidae) - longnosed butterflyfish (*Forcipiger flavissimus*) and butterflyfish (*Chaetodon* sp.); parrotfish (scaridae); and poison-fang blenny (*Meiacanthus atrodorsalis* - blenniidae).

40-Foot Depth (OH-1)

At a depth of 40 feet, the reef face was steeply sloping or nearly vertical with many overhanging ledges and caves that created some complexity at a variety of scales. Sand

and silt (12%) occurred in a couple chutes with rubble but also covered some of the horizontal surfaces. A tuft of fleshy, red algae (<1%) occurred near the beginning of the transect, a few hydroids (<1%) seemed anchored to the ceiling of a cave, and sponges (2%) occurred throughout the transect. Most solid surfaces were probably encrusted by coralline algae (maybe 38%), encrusting sponges (maybe 10%) and possibly ascidians (maybe 13%). A soft, fanlike colony, possibly a gorgonian (gorgonacea) (<1%) was seen in a cave. Scleractinian corals were encrusting and laminar types and included *Montipora* (12%), *Echinopora* (6%), *Porites* (3%) and *Astreopora* (<1%). Damselfishes (pomacentridae) and the regal angelfish (*Pygoplites diacanthus* - pomacanthidae) were seen near the transect.

60-Foot Depth (OH-1)

At a depth of 60 feet, the transect crosses a slope of mostly rubble and silt, periodically interrupted by solid coral formations at the base of the reef wall. The habitat has little complexity. Overall, silt and sand (70%) dominated the benthic coverage, sometimes mixed with rubble or on solid horizontal surfaces. Sponges (1%) were not common, and silt-free surfaces were probably encrusted with coralline algae (maybe 9%), ascidians (maybe 9%) and encrusting sponges (maybe 9%). Living scleractinian coral was limited to a couple of small encrusting colonies, probably *Montipora* (<1%) and *Porites* (<1%). Several fishes were seen in the area, including princess damsel (*Pomacentrus vaiuli*), butterflyfishes (*Chaetodon* sp. - chaetodontidae), bicolor angelfish (*Centropyge bicolor* - pomacanthidae), regal angelfish (*Pygoplites diacanthus* - pomacanthidae), surgeonfishes (acanthuridae), wrasses (labridae) and blue-spot grouper (*Cephalopholis argus* - serranidae).

OUTER HARBOR: Station OH-5 Transects

25-Foot Depth (OH-5)

At a depth of 25 feet, the habitat was a complex array of large and small coral formations with a variety of crevices and holes typical of a spur and groove reef front below the reef break. An encrusted rope crossed the transect. Silt (<1%) was noted in only one small pocket under a large coral formation. Solid substrate appeared consolidated by coralline algae (maybe 52%), encrusting sponges (maybe 10%) and ascidians (maybe 10%). Sponges (2%) occurred throughout the transect and a few tufts of calcareous algae (<1%) were seen. The non-scleractinian, stinging coral, Millepora (hydrocorallina) (2%) encrusted a patch of substrate. Living scleractinian corals were mostly encrusting colonies of Montipora (10%), Porites (3%) and unidentified faviidae (<1%), but small colonies of Pocillopora (5%) were common, and Fungia (<1%), Diploastrea heliopora (<1%) and a delicately branching Acropora (<1%) also occurred. A variety of fishes were observed in the area including surgeonfishes (acanthuridae), goatfishes (mullidae) and parrotfishes (scaridae). Several damselfishes (pomacentridae) occurred, including blue devils (Chrysiptera cyanea), farmerfish (Stegastes sp.), sergeants (Abudefduf sp.) and black-and-white damsels (Chromis sp.). Vagabond butterflyfish (Chaetodon vagabundus - chaetodontidae) and long-nosed butterflyfish (Forcipiger sp. chaetodontidae), large-eyed bream (Monotaxis grandoculus - lethrinidae) and sixbar wrasse (Thalassoma hardwickii - labridae) were also seen.

40-Foot Depth (OH-5)

At a depth of 40 feet, the spur and groove topography contributes to the somewhat complex habitat with a variety of holes and crevices. Silt (<5%) was rare and mostly limited to the floor of a cave and a rubble channel. Encrusting organisms consolidated some of the larger rubble and probably included coralline algae (30%), encrusting sponges (maybe 10%) and ascidians (maybe 10%). Sponges (4%) were intermittently abundant, and a patch of greenish algae (<1%) also occurred. The live scleractinian coral cover was dominated by encrusting and small, laminar colonies, probably including *Montipora* (25%), *Echinopora* (5%), *Porites* (4%) and an unidentified faviid (3%), but *Fungia* (<1%), *Pocillopora* (<1%) and a delicately branching *Acropora* (1%) were also seen. Fishes in the area of the transect included surgeonfish (*Acanthurus* sp. - acanthuridae), unicornfish (Naso sp. - acanthuridae), vagabond butterflyfish (*Chaetodon vagabundus* - chaetodontidae), long-nosed butterflyfish (*Forcipiger* sp. - chaetodontidae), blue devil (*Chrysiptera cyanea* - pomacentridae), farmerfish (*Stegastes* sp. - pomacentridae) and regal angelfish (*Pygoplites diacanthus* - pomacanthidae).

60-Foot Depth (OH-5)

At a depth of 60 feet, the habitat was composed mostly of rubble and silt with a few patches of semi-consolidated coral formations providing the majority of the sparse complexity. Sand and silt (85%) covered most rubble and solid surfaces and in places it appeared to be consolidated by epiphytes, probably hydroids (1%). Coralline algae (maybe 3%), encrusting sponges (maybe 1%) and ascidians (maybe 1%) may have lived on some of the silt-free, solid substrate. Sponges (2%) were encountered throughout the transect and a few tufts of fleshy red algae (<1%) were seen. Living scleractinian corals consisted of a few small, laminar and encrusting colonies of *Montipora* (maybe 3%), *Porites* (maybe 2%) and *Diploastrea heliopora* (<1%). A small colony of *Galaxea* was seen just off the transect. Fishes at this depth included farmerfish (*Stegastes* sp. - pomacentridae), surgeonfishes (acanthuridae), bicolor angelfish (*Centropyge bicolor* - pomacanthidae), star pufferfish (*Arothron stellatus* - tetraodontidae) and poison-fang blenny (*Meiacanthus atrodorsalis* - blenniidae).